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Operating Manual

MODEL TCA-1

TRANSFARAD CAPACITOR ANALYZER

1. General Description

1.1 Purpose and Usefulness. The TCA-1 was designed specifically to enable design engineers, inspection departments and service engineers to test all types of capacitors (electrolytic, film, and ceramic) used in transistor circuits without harm to the capacitor regardless of voltage rating. It incorporates in one compact instrument a multi-range capacitance and power factor bridge, an insulation resistance checker for film, paper, mica and ceramic capacitors, and a leakage current test circuit for electrolytic (including all types of tantalum) capacitors. All functions are selected by a single knob, and a magic eye indicator simplifies bridge balancing for capacitance and power factor measurements. The large meter gives direct readings of insulation resistance and leakage current, and shows the exact voltage applied to electrolytic capacitors during the leakage test.

1.2 The especially valuable features incorporated into the TCA-1 are:

- a. The low a-c voltage applied to the bridge circuit during the capacitance and power factor measurements is 0.5 volts. The actual a-c voltage across the capacitor is therefore less than 0.5 volts depending upon the magnitude of the capacitance being measured;
- b. The special low capacitance circuit for measuring low values of ceramic and mica capacitors (from 1 mmf to 100 mmf) with improved accuracy;
- c. The insulation resistance test with a range up to 20,000 megohms with only 25 volts applied to the test circuit;
- d. Provision for measuring the insulation resistance of even 3 volt ceramic capacitors without over-stressing the insulation;
- e. The high gain meter amplifier which provides a full scale sensitivity of $0.6 \mu\text{A}$ for measuring the leakage current of low voltage electrolytic and ceramic capacitors;
- f. The etched circuit and encapsulation techniques which make possible the high-gain and long-time stability of the meter amplifier;
- g. The voltage regulator (magnetic and electronic) which contributes in a large measure to the stability and accuracy of the instrument even though the line voltage varies from 105 to 125 volts;
- h. The high-gain null detector amplifier with a gain control thus enabling the user to select the best combination of detector sensitivity and ease of operation for his particular application;
- i. Automatic discharge of the capacitor under test;
- j. Shielding of small capacitors under test to prevent errors due to stray pick-up;
- k. Overload protection of the meter;
- l. Easily followed operating procedures shown on the pull-out slide at the base of the instrument.

1.3 Capacitance. In addition to the special low range mentioned above, four other capacitance ranges are provided for measurements up to 2000 mf. With the TCA-1 you can safely and easily test (for all characteristics) all types of capacitors used in transistor circuits (aluminum and tantalum electrolytics, film capacitors, and ceramic capacitors, including the 1 and 3 volt types) of computers and other types of industrial electronic equipment as well as in ultra-miniature radio sets and hearing aids.

1.3.1 Power Factor. The power factor of all electrolytics is indicated directly on the panel.

1.4 Leakage Current. A self-contained, regulated, continuously adjustable d-c power supply permits measurement of the leakage current of all transistor-type electrolytic capacitors at exact rated voltage.

1.5 Insulation Resistance. The electronic measurement circuit reads IR directly from 50 to 20,000 megohms, covering the wide range necessary for testing ceramic, mica, air, paper, film, or paper-film capacitors, as well as cables and other insulating material used in electronic equipment.

1.6 Line Voltage and Frequency. The Model TCA-1 Transfarad is designed for use on 105-125 volt, 60 cycle lines ONLY. It will NOT operate on 25 or 50 cycle lines of any voltage. A step-down transformer rated for at least 50 watts is necessary for operation on 230 volt, 60 cycle lines.

1.6.1 The TCA-1 is supplied with a 3-wire line cord to automatically ground the case when the plug is inserted into a 3-prong power receptacle. In the case of 2-prong receptacles, an adaptor, available from all electronic distributors, should be used with the ground wire connected to the screw on the receptacle plate.

1.7 Not For Use On Direct Current. Under NO circumstances should TCA-1 be plugged into a d-c outlet. Always use an inverter power supply (either transistor or other type) that will supply exactly 60 cycles. The supply must be capable of supplying at least 50 watts at 105-125 volts.

1.8 Physical Appearance. The blue-gray hammertone finish steel case, with leather carrying handle, and the light gray panel with red and black markings, along with the charcoal dial (white lettering) and plastic indicator make the Model TCA-1 an instrument that will command respect wherever it is used. The overall size of the Transfarad is 8 $\frac{7}{8}$ in. high x 14 $\frac{5}{8}$ in. wide x 9 in. deep.

1.9 Weight. The net weight of the TCA-1 is 27 lbs.

1.10 Electron Tubes. The electron tube complement of each Transfarad consists of two each 12AT7 and OB2, and one each 6AU6, 6CG7, 6X4, 1629, OA2 and No. 51 lamp.

1.11 Components. The components used in the TCA-1 were chosen for suitability and dependability. Sprague molded Difilm® capacitors, Koolohm® resistors, and Filmistor® molded carbon-film resistors are used wherever appropriate. Ceramic trimmer and stabilized silver mica capacitors are used as low-capacitance standards. The meter amplifier is mounted on an etched board and then completely encapsulated to exclude moisture and insure long-time stability. Switches were especially chosen for the moisture resistance of the dielectric used. The transformers are impregnated with a special moisture-proofing compound. Metal parts are suitably painted or plated as required to resist corrosion.

2. Capacitance and Power Factor

2.1 Measurements of capacitance from 1 mmf to 2000 mf are made on a 5-range line frequency capacitance bridge. Figure 1 shows a simplified circuit diagram of the bridge employed for the C_1 , C_2 and C_3 ranges. Figure 2 shows the basic circuit for the C_4 range, and Figure 3 is the circuit for the C_5 range. Since the bridge is balanced on all ranges by continuously varying the ratio arm, a highly accurate, linear-taper wirewound variable resistor is used for the main bridge element, R_{46} . These resistors are especially selected to assure proper accuracy of the calibrated dial. In addition, trimming resistors are provided at each end of the control (not shown on the basic circuits). The standard capacitors for the C_1 and C_2 ranges are stabilized silver-mica capacitors paralleled by silver-ceramic trimmers which are factory adjusted to compensate for variations in wiring capacitance. The C_3 and C_4 standards are matched pairs of Sprague DIFILM[®] molded tubular capacitors. R_{42} in the basic circuit is the sensitivity control for the amplifier which, along with the "magic-eye", tube constitutes the bridge balance indicator.

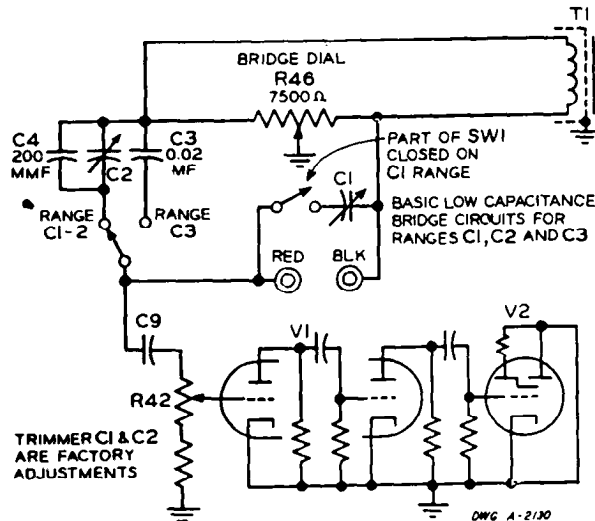


FIGURE 1

Basic Low Capacitance
Bridge Circuit for Ranges
 C_1 , C_2 , and C_3 .

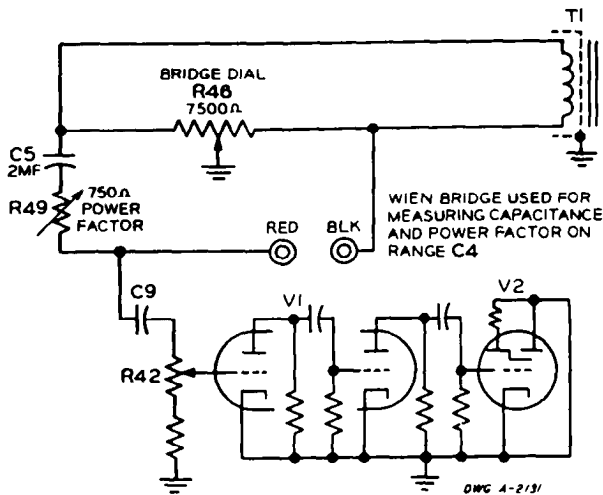


FIGURE 2

This Wien Bridge is used
for measuring capacitance
and power factor on
Range C_4 .

(3) Turn the SELECTOR knob to the CALIBRATE position, and turn the NORMAL-SET METER knob to SET METER. Adjust the POLARIZING VOLTAGE FINE knob (under meter) so that the meter reads SET. Return the NORMAL-SET knob to NORMAL, and rotate the ADJUST knob (adjacent to Pilot Light) until the meter again reads SET.

(4) Recheck zero as in (2) above.

(5) Turn the SELECTOR knob to SET INS. RES., and rotate the POLARIZING VOLTAGE FINE knob until the meter reads SET.

(6) Turn the SELECTOR knob to READ INS. RES., and rotate the ZERO ADJUST knob so that the meter reads zero. Recheck (5). Connect the capacitor to the binding posts and read the insulation resistance in megohms on the red scale of the meter. Capacitors rated above $.1\mu\text{F}$ require an appreciable time to become charged. When testing such capacitors, several minutes should be allowed for the meter reading to reach a stable value.

(7) To discharge the capacitor under test, rotate the SELECTOR switch to the SET INS. RES. position. It may then be removed from the posts without danger of shock.

4. Leakage Current of Electrolytic Capacitors

4.1 The basic circuit for the meter amplifier calibration is shown in Figure 5. The amplifier is designed so that an input of .09 volts will produce full scale deflection of the meter. In order to maintain accuracy as tubes age or are replaced, it is necessary to check the gain and correct it if needed. This is accomplished in the calibration circuit.

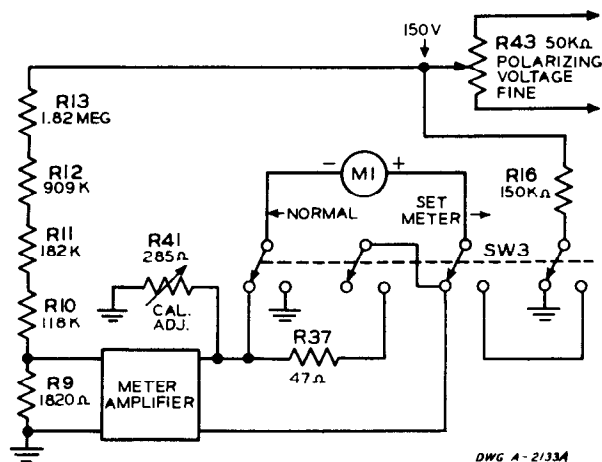


FIGURE 5

This is the basic circuit for the meter amplifier calibration.

4.1.1 In the SET METER position of the NORMAL-SET METER switch, the meter M_1 is in series with R_{16} (a 1% Filmistor) and is used as a basic voltmeter to accurately set the potential applied to the input of the amplifier. In the NORMAL position of the switch, the meter is in the amplifier output circuit, and the gain is adjusted by the ADJUST control (R_{11}) to give full scale meter deflection thereby preventing any errors due to incorrect amplifier gain.

4.2 The basic circuit used to obtain the polarizing voltage for the Leakage Current test is shown in Figure 6. This voltage is continuously variable from 0-150 volts, and is controlled by the "COARSE" switch (4 steps) and the "FINE" control which gives full variation within each step.

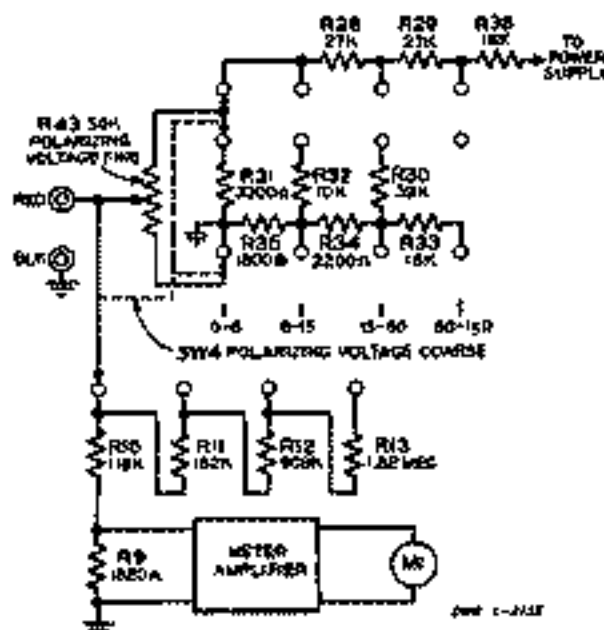


FIGURE 6

This is the basic circuit for measuring the polarizing voltage of electrolytic capacitors.

4.2 The basic circuit for the measurement of leakage current of electrolytic capacitors is shown in Figure 6. The meter amplifier has seven different values of input resistance in order for the meter to read leakage currents ranging from 0.6 to 600 microamperes (full scale values - in seven ranges). The first scale division is $0.02 \mu A$. Thus $0.1 \mu A$ can be read accurately. The input circuit has a constant voltage drop, on all ranges, of 0.9 volts. This is particularly important when testing very low voltage capacitors in the 1 or 2 volt range.

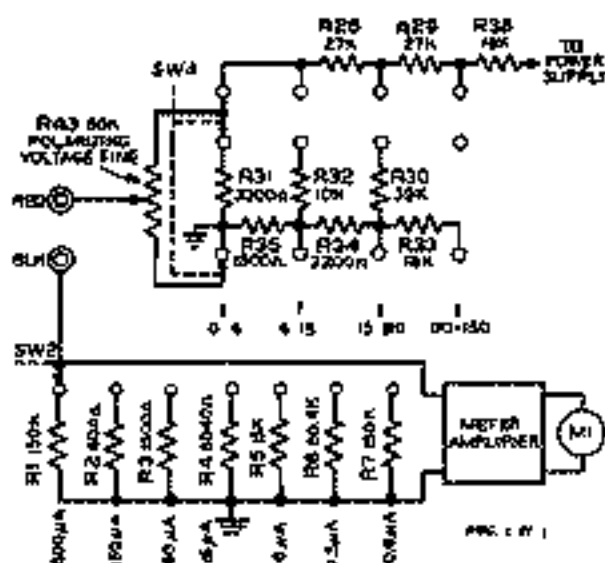


FIGURE 7

This is the basic arrangement for measuring the leakage current of electrolytic capacitors.

4.4 Operating Procedure

- (1) Calibrate the TCA-1 as in Section 3.2.
- (2) Rotate the SELECTOR knob to POLARIZING VOLTAGE, and adjust the POLARIZING VOLTAGE COARSE and FINE knobs so that the meter reads the rated d-c voltage of the capacitor to be tested.
- (3) Determine that the LEAKAGE CURRENT knob is in the 600 position. It should be kept in this position, unless the control is in use, even though the meter is over-load protected.
- (4) Connect the capacitor to be tested to the binding posts observing polarity.
- (5) Rotate the SELECTOR knob to the LEAKAGE CURRENT position, and note the meter reading. Allow the reading to become stable (it may take as long as 5 minutes) and if it is less than 150 μA , rotate the LEAKAGE CURRENT switch to the 150 μA position, or to a lower current range until the meter reading is on the upper portion of the scale. The leakage current is then read directly from the scale.
- (6) If the initial current reading is high, after it stabilizes, rotate the SELECTOR knob back to the POLARIZING VOLTAGE position and readjust the FINE control, if necessary, to bring the meter reading to the exact value of the d-c voltage rating of the capacitor.
- (7) Repeat (5) and obtain the final reading.
- (8) The leakage current of new transistor-type capacitors is quite small compared with the currents encountered in the case of the higher voltage types. The capacitor manufacturer's specifications or equipment service manual should be consulted for permissible leakage data. In the absence of such information, the average leakage current for new capacitors may be computed from the formula: $I = kCE$ where I is in μA , C in mf, E in volts, and k is a constant for a given capacitor (it is different for the various types of capacitors and, in general, increases with temperature). The following values of k will serve as a guide (all values are for 25C):

	k
Tantalum foil (plain)	.02
Tantalum foil (etched)	.01
Tantalum sintered anode	.003
Tantalum solid electrolyte	.02

- (9) The leakage of new subminiature aluminum capacitors may be expected to be as shown below:

3VDC	1 μA
12VDC	2 μA
25VDC	3 μA
150VDC	15 μA

- (10) Capacitors with obviously excessive leakage or those whose leakage does not reach a stable value should be replaced.
- (11) To discharge the capacitor under test, rotate the SELECTOR switch to the SET INS. RES. position. It may then be removed from the post without danger of shock.

5. Insulation Resistance of Low Voltage Ceramic Capacitors

5.1 The IR of low voltage (under 25VDC) ceramic capacitors may be determined by measuring the leakage current at the rated voltage of the capacitor, as outlined above, and computing the insulation resistance

from Ohms' Law, $R = \frac{E}{I}$

6. Miscellaneous Hints

6.1 As noted on the panel, the "eye" glows only when the bridge portions of the TCA-1 are used ($C_1 - C_5$ positions of the SELECTOR switch). It does NOT glow when measurements of insulation resistance or leakage current are being made.

6.2 To avoid parallax error, always read the main dial with your eye directly in front of the indicator line. Reading from an angle will introduce errors.

6.3 For maximum accuracy of capacitance readings, when there is a choice of bridge scales use the range which will give a balance near the center of the scale.

6.4 For best accuracy when reading voltage or current on the meter, when there is a choice, use the range that gives a reading on the upper portion of the scale.

6.5 Return your TCA-1 Registration Card within five (5) days of the date of purchase in order to obtain the benefits of the Sprague warranty.

6.6 Always give model and serial number of your Transfarad, when corresponding concerning your instrument. The serial number is on the rear of the chassis below the line cord.

6.7 If it should ever be necessary to return your TCA-1 for recalibration or service, *write for detailed shipping instructions* BEFORE returning the instrument. *You will save time and money by this procedure.* Always attach a tag giving details of how the instrument is malfunctioning.

LIST OF MAINTENANCE PARTS FOR TCA-1

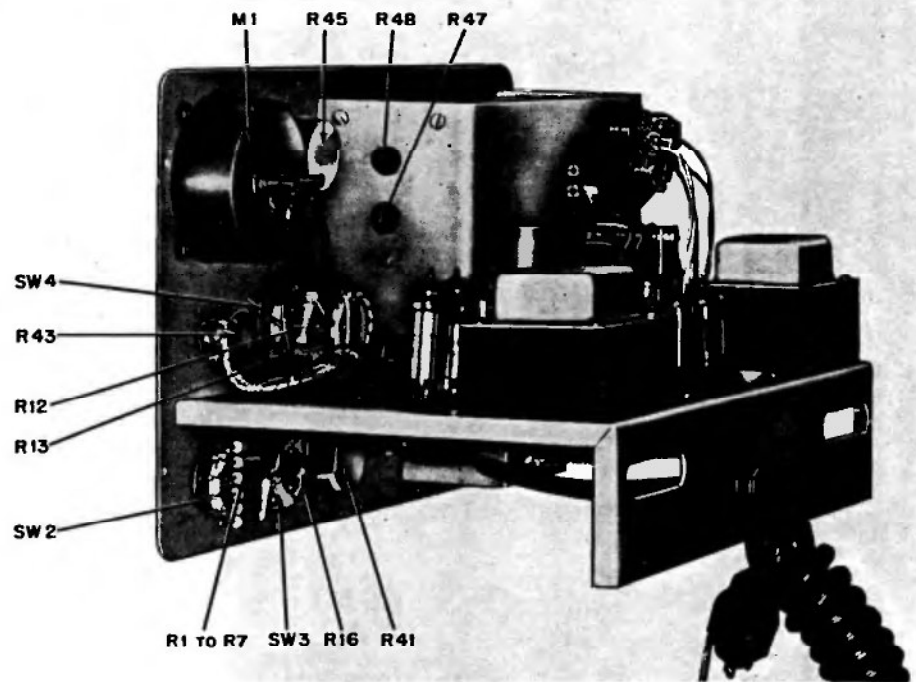
Circuit Symbol	Replacement Part No.	Description
C ₁ } C ₂ }	1-1000	Capacitor, adjustable dual trimmer, silver ceramic, 4-30 mmf.
C ₃	1-202A	Capacitor, fixed, molded Difilm, .02 mf., picked to $\pm 1\%$, 600 vdc. Sprague No. 6TM-S2.
C ₄	1-865	Capacitor, fixed, silver-mica, 200 mmf $\pm 5\%$, 500 vdc Sprague No. MS-32
C ₅	1-208A	Capacitor, fixed, Difilm, 2 mf., $\pm 1\%$, 400 vdc. Consists of two or three matched parallel capacitors.
C ₆ } C ₇ }	1-382	Capacitor, fixed, .02 mf., $\pm 10\%$ 600 vdc. Sprague No. 6TM-S2
C ₈ } C ₁₀ } C ₁₁ }	1-383	Capacitor, fixed, .033 mf., $\pm 10\%$, 600 vdc. Sprague No. 6TM-S33
C ₁₂ } C ₁₃ }	1-525	Capacitor, fixed, dry electrolytic, 100 mf, 3 vdc. Sprague Type TVL.
C ₁₄	1-525	Capacitor, fixed, dry electrolytic, 20 mf, 250 vdc. Sprague Type TVL.
C ₁₅	1-1110	Capacitor, fixed, Clorinol, 1 mf., 660 vac. Sprague No. 200P225
C ₁₆ } C ₁₇ }	1-524	Capacitor, fixed, dry electrolytic, Sprague No. TVL2762 with insulating cover 40 + 20 mf @ 450 vdc.
F ₁	7-501	Fuse, cartridge, 1 Amp., Type 3AG
Meter Amp.	15-40WP	Direct current meter amplifier unit.
M ₁	7-15	Milliammeter, 0-1 ma, d-c $\pm 2\%$, special scale
R ₁	2-29A	Resistor, fixed, deposited carbon, 150 Ω , $\pm 1\%$, $\frac{1}{2}$ watt, Sprague No. 407E150R1
R ₂	2-982	Resistor, fixed, deposited carbon, 604 Ω , $\pm 1\%$, $\frac{1}{2}$ watt, Sprague No. 407E604R1
R ₃	2-53A	Resistor, fixed, deposited carbon, 1500 Ω , $\pm 1\%$, $\frac{1}{2}$ watt, Sprague No. 407E15011
R ₄	2-983	Resistor, fixed, deposited carbon, 6040 Ω , $\pm 1\%$, $\frac{1}{2}$ watt, Sprague No. 407E60411
R ₅	2-77A	Resistor, fixed, deposited carbon, 15,000 Ω , $\pm 1\%$, $\frac{1}{2}$ watt, Sprague No. 407E15021
R ₆	2-984	Resistor, fixed, deposited carbon, 60,400 Ω $\pm 1\%$, $\frac{1}{2}$ watt, Sprague No. 407E60421

LIST OF MAINTENANCE PARTS—Continued

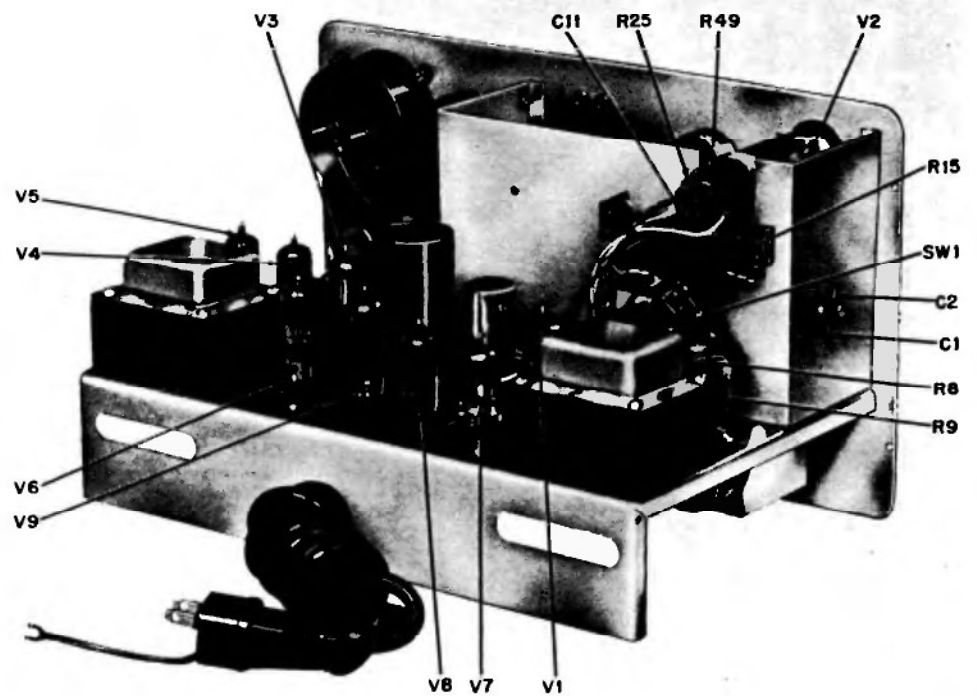
Circuit Symbol	Replacement Part No.	Description
R ₇ } R ₁₄ } R ₁₆ }	2-101A	Resistor, fixed, deposited carbon, 150,000Ω, ±1%, ½ watt, Sprague No. 407E15031
R ₈ } R ₁₃ }	2-985	Resistor, fixed, deposited carbon, 1.82 megohms, ±1%, 1 watt, Sprague No. 408E18241
R ₉	2-986	Resistor, fixed, deposited carbon, 1820Ω, ±1%, ½ watt, Sprague No. 407E18211
R ₁₀	2-987	Resistor, fixed, deposited carbon, 118,000Ω, ±1%, ½ watt, Sprague No. 407E11831
R ₁₁	2-988	Resistor, fixed, deposited carbon, 182,000Ω, ±1%, ½ watt, Sprague No. 407E18231
R ₁₂	2-989	Resistor, fixed, deposited carbon, 909,000Ω, ±1%, ½ watt, Sprague No. 407E90931
R ₁₅	2-990	Resistor, fixed, molded, 500 megohms, ±5%, 2½ watts, Sprague type 702E
R ₁₇ } R ₃₆ }	2-109	Resistor, fixed, composition, 330,000Ω, ±10%, ½ watt
R ₁₈	2-91	Resistor, fixed, composition, 56,000Ω, ±10%, ½ watt
R ₁₉ } R ₂₂ } R ₂₀	2-65	Resistor, fixed, composition, 4700Ω, ±10%, ½ watt
R ₂₃ } R ₂₅ } R ₂₇ }	2-113	Resistor, fixed, composition, 470,000Ω, ±10%, ½ watt
R ₂₁ } R ₂₄ }	2-121	Resistor, fixed, composition, 1 megohm, ±10%, ½ watt
R ₂₆ } R ₃₄ }	2-57	Resistor, fixed, composition, 2200Ω, ±10%, ½ watt
R ₂₈ } R ₂₉ }	2-83	Resistor, fixed, composition, 27,000Ω, ±10%, ½ watt
R ₃₀	2-87	Resistor, fixed, composition, 39,000Ω, ±10%, ½ watt
R ₃₁	2-61	Resistor, fixed, composition, 3300Ω, ±10%, ½ watt
R ₃₂	2-73	Resistor, fixed, composition, 10,000Ω, ±10%, ½ watt
R ₃₃ } R ₃₈ }	2-79	Resistor, fixed, composition, 18,000Ω, ±10%, ½ watt
R ₃₅	2-55	Resistor, fixed, composition, 1800Ω, ±10%, ½ watt

LIST OF MAINTENANCE PARTS—Continued

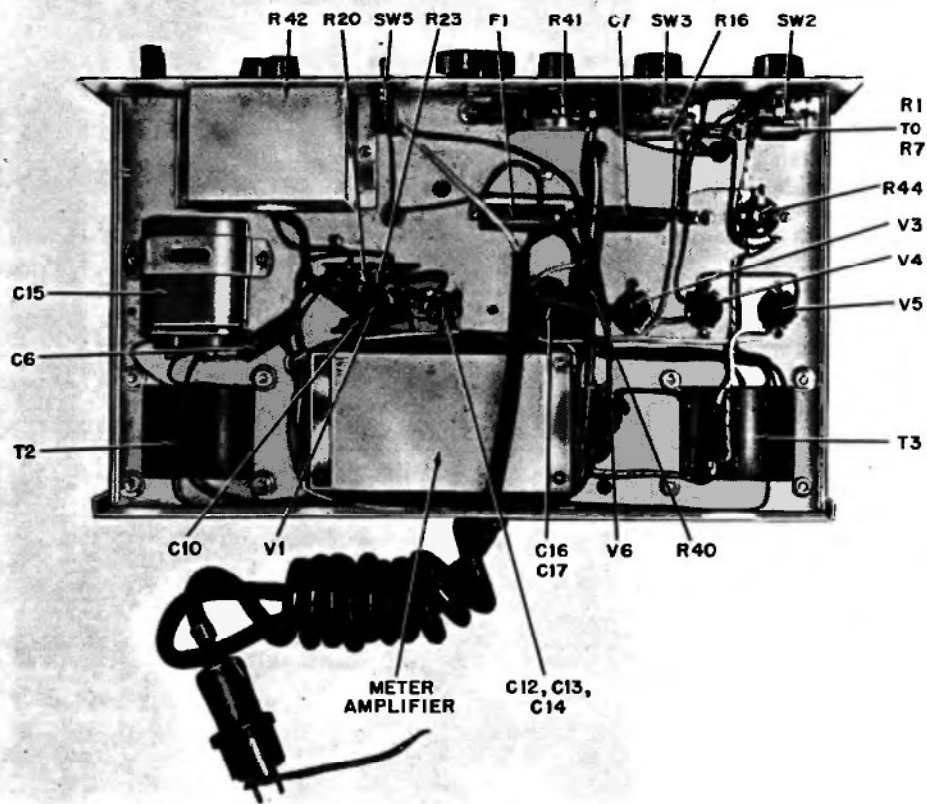
R ₃₇	2-17	Resistor, fixed, composition, 47 Ω , $\pm 10\%$, $\frac{1}{2}$ watt
R ₃₈	2-548	Resistor, fixed, composition, 1000 Ω , $\pm 10\%$, 1 watt
R ₄₀	2-556	Resistor, fixed, composition, 2200 Ω , $\pm 10\%$, 2 watt
R ₄₁	2-1031	Resistor, continuously adjustable, wire-wound, 285 Ω , $\pm 10\%$, linear taper, 2 watts, 300° mechanical rotation, 280° electrical rotation
R ₄₂	2-1003	Resistor, continuously adjustable, composition, 500,000 Ω , $\pm 20\%$, linear taper, $\frac{1}{2}$ watt
R ₄₃	2-1051	Resistor, continuously adjustable, composition, 50,000 Ω , $\pm 20\%$, linear taper, $\frac{1}{2}$ watt
R ₄₄	2-1065	Resistor, continuously adjustable, wire-wound, 1000 Ω , $\pm 20\%$, $1\frac{1}{2}$ watts, screwdriver adjustment
R ₄₅	2-1015	Resistor, continuously adjustable, wire-wound, 2000 Ω , $\pm 20\%$, linear taper, 2 watts
R ₄₆	2-1020C	Resistor, continuously adjustable, wire-wound, 7500 Ω , $\pm 10\%$, linear taper, 3 watts, 300° mechanical rotation, 280° electrical rotation. Selected for agreement with calibrated dial
R ₄₇ }	2-1064	Resistor, continuously adjustable, wire-wound, 100 Ω , $\pm 20\%$, $1\frac{1}{2}$ watts
R ₄₈ }		
R ₄₉	2-1013	Resistor, continuously adjustable, wire-wound, 750 Ω , $\pm 10\%$, 2 watts, linear taper, 300° mechanical rotation, 280° electrical rotation
SW ₁	11-188	Switch, rotary, 11 position
SW ₂	11-193	Switch, rotary, 7 position
SW ₃	11-192	Switch, rotary, 2 position
SW ₄	11-191	Switch, rotary, 4 position
SW ₅	11-6	Switch, toggle, SPST
T ₁	3-108-1	Transformer, bridge supply
T ₂	3-108-2	Choke, regulating type
T ₃	3-108-3	Transformer, filament and power, regulating type
V ₁ }	5-12AT7	Tube, electron, 12AT7
V ₇ }		
V ₂	5-1629	Tube, electron, 1629
V ₃	5-OA2	Tube, electron, OA2
V ₄ }	5-OB2	Tube, electron, OB2
V ₅ }		
V ₆	5-6X4	Tube, electron, 6X4
V ₈	5-6AU6	Tube, electron, 6AU6
V ₉	5-6CG7	Tube, electron, 6CG7
PL	5-51	Pilot Lamp, No. NE 51



VIEW FROM LEFT REAR



VIEW FROM RIGHT REAR



BOTTOM VIEW OF CHASSIS

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